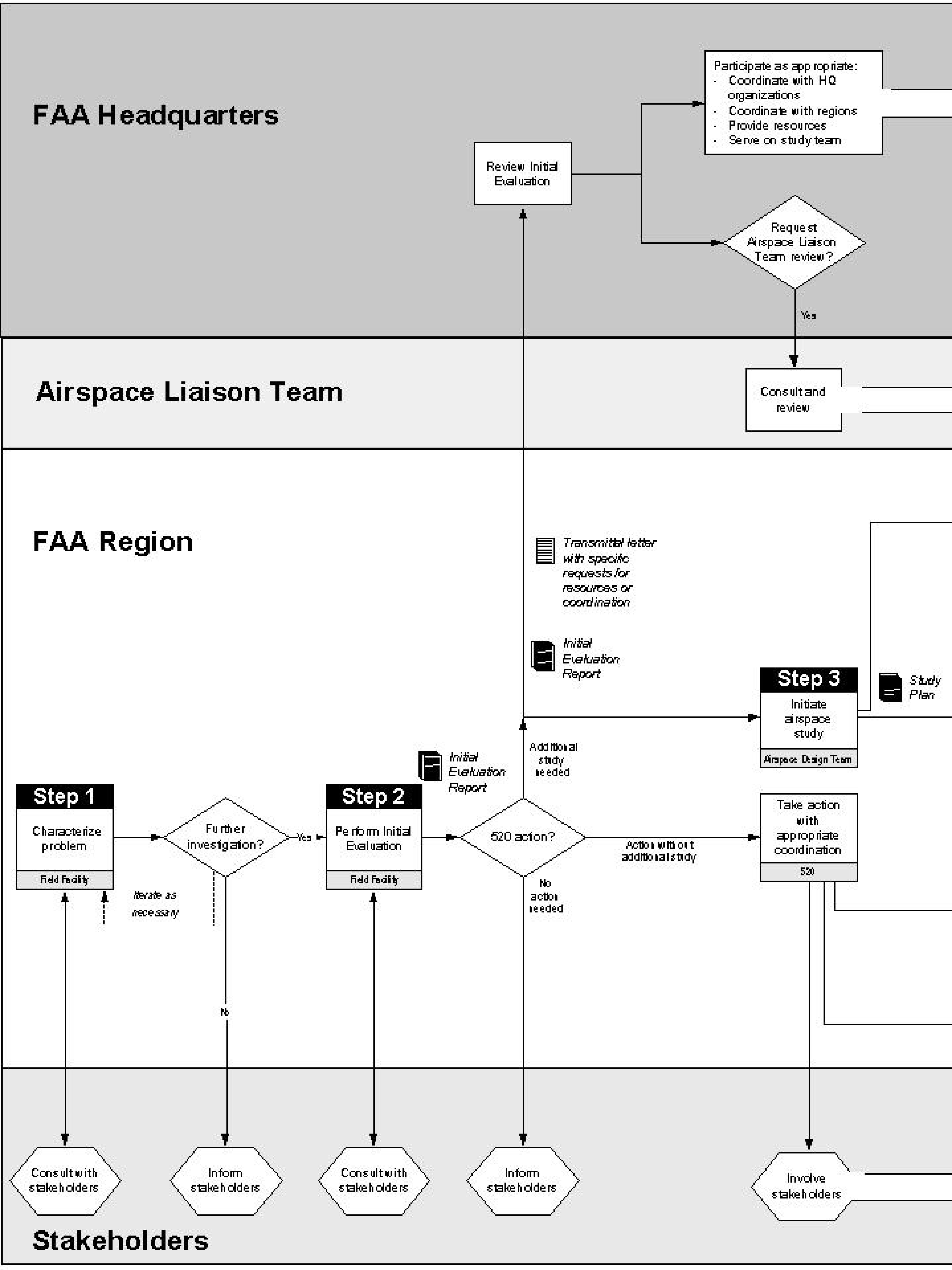
AIRSPACE MANAGEMENT HANDBOOK

GUIDELINES

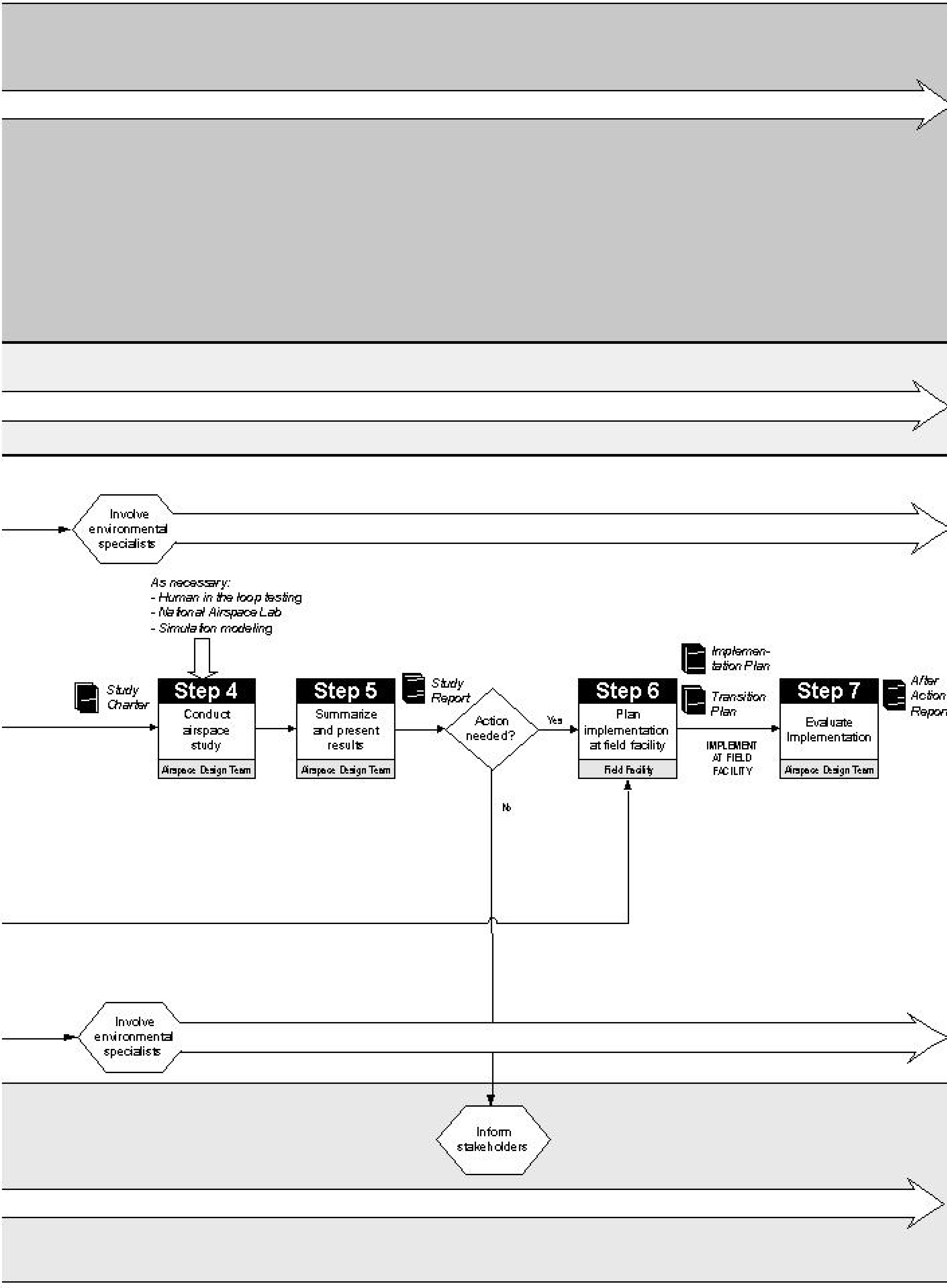
The Airspace Management Handbook – consisting of these guidelines and the associated checklist – has been prepared primarily for the specialists in the field who may have to initiate or participate in the process of making changes to the airspace structure. These specialists may be working in the regional offices, an air route traffic control center (ARTCC), a terminal radar approach control (TRACON), or an air traffic control tower (ATCT). This handbook will also be provided to members of the Air Traffic Services (ATS) offices at FAA Headquarters, as well as to the many stakeholders in the aviation community. Stakeholders are those who may be impacted by a change in the airspace structure, including airspace users (i.e., the major air carriers, regional carriers, general aviation, and the military), air traffic service providers (i.e., air traffic controllers, adjacent facilities, airport operators, and the military), and others such as local communities, special interest groups, and federal, state and local agencies.

These guidelines include a two-page pictorial representation of the overall process associated with proposed changes to the airspace structure. Each of the seven steps identified in the process is further explained and amplified herein. Included in these guidelines are references to other, more-detailed documents, that provide even more amplification on some elements of the airspace manage-ment process.

Questions or suggestions concerning this handbook should be directed to:
Federal Aviation Administration
Office of Air Traffic Airspace Management
Planning and Analysis Division (ATA-200)
800 Independence Avenue, SW
Washington, DC 20591



FAA Headquarters
Review Initial Evaluation
Participate as appropriate:
- Coordinate with HQ organizations
- Coordinate with regions
- Provide resources
- Serve on study team
Request Airspace Liaison Team review?
Yes
Airspace Liaison Team
Consult and review
FAA Region
Transmittal letter with specific requests for resources or coordination
Initial Evaluation Report
Step 3
Initiate airspace study
Airspace Design Team
Study Plan
Additional study needed
Initial Evaluation Report
Step 1
Characterize problem
Field Facility
Further investigation?
Yes
Step 2
Perform Initial Evaluation
Field Facility
520 action?
Action without additional study
Take action with appropriate coordination
520
Iterate as necessary
No action needed
No
Consult with stakeholders
Inform stakeholders
Consult with stakeholders
Inform stakeholders
Involve stakeholders
Stakeholders



Involve environmental specialists
As necessary:
- Human in the loop testing
- National Airspace Lab
- Simulation modeling
Study Charter
Step 4
Conduct airspace study
Airspace Design Team
Step 5
Summarize and present results
Airspace Design Team
Study Report
Action needed?
Yes
No
Implementation Plan
Transition Plan
Step 6
Plan implementation at field facility
Field Facility
IMPLEMENT AT FIELD FACILITY
Step 7
Evaluate Implementation
Airspace Design Team
After Action Report
Involve environmental specialists
Inform stakeholders

CHECKLIST

____ **1** **CHARACTERIZE PROBLEM**
What is the true nature and extent of the problem?

____ **2** **PERFORM INITIAL EVALUATION**
Identify and evaluate alternatives and make recommendations.

____ **3** **INITIATE AIRSPACE STUDY**
Establish airspace design team, write a charter, and develop a study plan.

____ **4** **CONDUCT AIRSPACE STUDY**
Alternatives, metrics, models, data ... and much more.

____ **5** **SUMMARIZE AND PRESENT RESULTS**
Convey the study results to the decisionmakers and the stakeholders.

____ **6** **PLAN IMPLEMENTATION AT FIELD FACILITY**
Carefully consider information exchange and transition issues.

____ **7** **EVALUATE IMPLEMENTATION**
Make sure the change accomplishes its intended purpose.

1 CHARACTERIZE PROBLEM

How are potential airspace structure problems first identified? Problems can be identified internally from within the FAA by the service providers. Problems can also be identified by sources external to the FAA, such as National Airspace System users, airport authorities, or communities. A request to examine a problem can arise from the perception that the airspace design (currently or in the future) contributes to traffic limitations, in-flight or ground delays, heavy controller workload, safety concerns, excessive noise, or other environmental concerns. Potential problems could be identified as a result of anticipated or planned changes to airports, equipment, procedures, or traffic patterns.

Some problems are identified reactively in response to the presence of a symptom, and other problems are identified proactively in anticipation of change. The matrix below shows examples of problems that arise from combinations of internal and external sources, along with reactive and proactive responses. Today, most problems are identified in a reactive mode from sources both internal and external to the FAA. The FAA continues to seek ways to improve the identification and evaluation process of airspace related metrics to support internal and proactive identification of latent problems. The ultimate goal is to solve latent problems before they become real problems to either the FAA or our customers.

Examples of Airspace Issues

	Reactive Response	**Proactive Response**
External Source	An airline complains about excessive delays at an airport.	An airline informs the FAA of its intent to alter operations in a specific way that could impact other operations.
Internal Source	An individual facility experiences workload imbalances.	The FAA must decide how, or if, to alter procedures to effectively incorporate the installation of a new system using advanced technology

In most cases, the FAA field facility or region that is affected by a problem or its solution will assume responsibility for examining the potential problem. Mandates from Congress or other government agencies usually are referred to FAA field facilities, either directly or after passing through FAA headquarters or regional offices. FAA headquarters will probably be responsible for issues that involve multiple regions or national airspace.

If a problem arises as part of a government mandate (Congress, federal departments or agencies, or state and local authorities), the lead organization (usually FAA headquarters or regional office), with support from the affected facilities, will be involved in developing a formal response. In cases where airspace issues are raised from within the aviation community, the FAA can investigate the true nature and extent of the problem before deciding whether or not to conduct a study. In some cases, the investigation of an issue will demonstrate that there is no problem once additional information is considered. In such cases, stakeholder(s) would be informed of the findings from the problem characterization step.

Characterization of the problem may also show that there is an issue, but of a different form than originally stated. A full characterization of the problem is crucial since it sets the stage for the subsequent phases of study. It is important to ensure that problem characterization does not simply repackage the original issue, but rather determines the true nature of the problem and identifies the root cause.

The approach for characterizing a problem should be tailored to fit the situation. The approach can be very simple, relying on past lessons learned and expert judgment, or it can be a sophisticated application of tools to analyze data. In all cases, some analysis will be required along the lines of the basic principles of the scientific method: develop a hypothesis, collect data, analyze the data, and draw conclusions about the original hypothesis.

The following types of analyses indicate the spectrum of approaches that could be applied to characterize the problem:

- Systematic investigation of anecdotal evidence, including conducting interviews, gathering data to complete the characterization, and applying expert judgment.
- Collection of data, followed by statistical analysis using spreadsheets or database tools, to quantify the type and extent of impacts.
- Use of graphical information system tools to allow visual analysis of flight paths.

Problem characterization may be an iterative process, with the possibility that any new investigation could open additional questions about the nature and extent of the problem. While it may initially appear that analysis of anecdotal evidence is the most appropriate way to characterize a problem, additional analysis could point to the need for investigation using other tools. The key is to allow the analysis to proceed in an iterative, flexible fashion to ensure that the problem is well characterized before proceeding to the next step.

Step 1, problem characterization, leads naturally to Step 2, initial evaluation of the problem. In some cases, the initial evaluation can also have implications for problem identification. For example, Step 1 could characterize a problem related to arrival and departure flows. Step 2 could determine that the initial problem as characterized is partially caused by interactions with en route flows, which may require additional characterization of the original problem. Thus, it may be necessary to revisit Step 1, depending on the results of the initial evaluation.

The role of stakeholders may be limited at this stage of an airspace analysis. The parties that originally raised the issue may be consulted to ensure that their concerns are given full consider-ation. It may also be appropriate to consult selected other stakeholders in order to complete the characterization, but there is no expectation that all possible stakeholders will be involved at this stage. As alternatives are identified and evaluated in subsequent stages, additional stakeholders may be included in the process.

2 PERFORM INITIAL EVALUATION

Not all problems or issues identified with the use of the National Airspace System (NAS) need to be resolved through a change in the airspace structure. As described in Step 1, the characterization of some perceived problems may show that they are not problems at all. Many real problems can also be resolved without resorting to changes in the airspace structure. Only when it is clearly indicated should changes to the airspace structure be considered. Initial evaluation is performed to develop various alternatives to solve the problems and to support (justify) the necessary action. As with all problems, NAS problems should be resolved in an expeditious manner with the least amount of effort and resources expended.

For problems that are specific to a field facility, the initial evaluation process should begin at that field facility. The initial evaluation, and perhaps the resolution of the problem, can some- times be conducted by a small group of people, using expert judgment and knowledge of the circumstances. Problems that involve multiple regions or national airspace may involve FAA headquarters in the initial evaluation.

The core of the initial evaluation is to further investigate the problem characterized in Step 1, and to determine whether additional study is necessary. All of the following elements should be documented in an initial evaluation:

Elements of an Initial Evaluation Report

Problem Statement	Describe the nature and severity of the problem, and the issues associated with the problem.
Background	Provide background on the problem being evaluated. The back-ground should identify the key stakeholders and their concerns.
Scope of the Initial Evaluation	Define the scope of the initial evaluation, especially with respect to constraints such as time, costs, resources, and tools. The scope will be influenced by the complexity of the changes evaluated, the size of the airspace involved, and the level of the potential impact of those changes.
Stakeholders	Identify the stakeholders that were consulted during the initial evaluation, and the input received from those stakeholders.
Technical Approach for the Initial Evaluation	Describe the technical approach used during the initial evaluation, including metrics, models, and data. Describe how environmental issues were evaluated.
Results and Conclusions	Document the results of the initial evaluation and the conclusions drawn from the initial evaluation.
Recommendations	Document the recommendations (for implementation, further study, or no action) that were developed as a result of the initial evaluation.

For issues initiated in field facilities, the initial evaluation is forwarded to the regional office air traffic division when completed. The regional office airspace manager will assess the initial evaluation and take action as described below depending on which of three possible recommendations results from the initial evaluation.

- **Initial evaluation determines that there is no action needed:**

  If no action is needed, the regional office airspace manager informs the stakeholders that were involved, provides an information copy of the initial evaluation report to ATA-200, and files the information for historical reference.

- **Initial evaluation determines that action can be taken with no further study:**

  The regional office airspace manager informs ATA-200 of the action to be taken within the region, and files the initial evaluation report for historical reference. The regional office airspace manager coordinates the action with the stakeholders and with the other regions as appropriate. See Step 6 of these guidelines on how to plan implementation of airspace changes at a field facility.

- **Initial evaluation determines that additional study is needed:**

  The regional office airspace manager forwards the initial evaluation report to ATA-200, along with a letter of transmittal that makes specific requests (including resources) and specific recommendations for coordination during the conduct of a formal airspace study.

  ATA-200 will review the initial evaluation report, coordinate with other headquarters organizations as necessary, and with other regional offices as necessary. ATA-200 may, in consultation with the Airspace Liaison Team, provide supporting resources as appropriate.

  If it is determined that a formal airspace study should be conducted, ATA-200 may, in consultation with the Airspace Liaison Team, determine the lead organization to conduct the study. Normally, the regional office airspace manager will be responsible for determining who will conduct the airspace study.

3 INITIATE AIRSPACE STUDY

The regional office airspace manager, or the lead organization for the airspace analysis, will establish an airspace design team that will be responsible for conducting the airspace study. The airspace design team may be made up of personnel from the affected facility(ies), regional personnel, FAA headquarters personnel, and stakeholders. If airspace controlled by or shared with other government organizations is involved, then that government organization should be represented on the airspace design team. The size of the airspace design team should mirror the complexity of the problem or issue to be dealt with. There is no limit as to the size or composition of the team, except as limited by budgets and schedules. It is highly recommended that the airspace design team either include individuals with prior experience in airspace design, or provide access to such individuals for guidance and insight into how alternatives can be identified and evaluated.

The airspace design team needs to include (or have access to) environmental expertise to identify and assist with environmental assessments as required. Representatives from regional offices and FAA headquarters will be available to advise the airspace design team on environ-mental issues.

Once established, the airspace design team should identify and contact relevant stakeholders and determine their roles and level of involvement. The amount of stakeholder involvement can range from periodic consultations to membership on the airspace design team. The degree of stakeholder involvement will depend on time and funding constraints, and the amount of interest expressed by the stakeholders. Identifying stakeholder concerns at this early stage allows the airspace design team to incorporate those concerns as part of the study charter and the study plan. The airspace design team must ensure that it complies with all sunshine laws, as well as the Federal Advisory Committee Act.

In conjunction with the regional office airspace manager, or the lead organization for the study, the airspace design team will first establish a study charter. The elements of the study charter are shown in the example outline that follows. The process of writing the study charter is the mechanism for the airspace design team to develop and record the structure and goals of the team. It also allows the team to determine if additional membership is needed. The draft study charter will be provided to FAA headquarters for review and coordination.

An example outline for a study charter is shown below.

Example Study Charter Outline

Problem Statement	Document the nature and severity of the problem, and the issues associated with the problem.
Background	Provide background on the problem or issue that the airspace design team has been formed to address. The background will identify the key stakeholders and their concerns, and discuss the events leading to the decision to form an airspace design team.
Scope of Study	Define the scope of the study, especially with respect to constraints such as time, costs, resources, and tools. The scope will be influenced by the complexity of the changes studied, the size of the airspace involved, and the level of the potential impact of those changes.

Objective(s) of the Airspace Design Team	Describe the objectives of the airspace design team in conducting the airspace study.
Stakeholders and Decisionmakers	Identify the stakeholders that will be involved with the study. Describe the relationship of the airspace design team to other organizational entities, including other regions and other study teams.
Roles and Responsibilities	Identify the members of the airspace design team, and define the roles and responsibilities of the individual members and of the airspace design team as a whole.
Products and Schedule	Describe the final products and the date by which the airspace study will be completed.
Resources for the Study	Estimate the resources (staff-years, dollars, models, data, etc.) that are anticipated to conduct the study.

The development of a comprehensive study plan is the next important step in an airspace analysis. Study plans may take different forms, depending largely on how complex or controversial the study may be or how long it will take. For simple, short, and non-controversial analyses, a study plan may simply take the form of a short staff paper or report of a few pages intended largely to define and communicate plans among key stakeholders and managers. For more complex or controversial efforts, a study plan may become very large in order to document the various stages and aspects of the study (i.e., concerns of potentially many different stake-holders and the specific conclusions regarding whether, when, how, and why specific concerns will and will not be addressed.)

> The development and coordination of the study plan with key stakeholders is *critically important for potentially controversial projects*. Such projects are often compromised late in the study when disagreements on various aspects of the study surface. The development of a study plan with stakeholder involvement can help to ensure important concerns are considered in formulating plans. It can also ensure that the pros and cons of proposed alternatives to address the concerns were fully discussed. The joint development of the study plan with stakeholders also can aid in developing "joint ownership" of the study and its results.

Resources and tools used should be appropriate to the scale of the problem being studied. Resources include FAA contractor support, computers and other equipment used for the study, and any materials procured for conducting the study. Tools refer to the items used to assist in the analysis, such as models and other software. The use of more complex airspace models may entail months of time and significant costs. Complex environmental studies also can be extremely costly. Before using the most rigorous models and extensive resources, the airspace design team should test whether or not their goals could be accomplished using tools with fewer demands on resources.

The study plan is likely to evolve through several iterations, and may even be altered after analyses have been started. The study plan should be considered a living document, and an archive of the various versions of the study plan should be maintained.

These guidelines, especially Step 4, should be carefully reviewed before developing the study plan, and the study plan should be tailored as appropriate to meet the specific needs of each individual study.

The table below presents an outline for an airspace analysis study plan. The outline lists the suggested contents for each component of the study plan. The study plan is an expansion and refinement of the study charter. Step 4 of these guidelines provides a discussion on determining the alternatives and on the technical approach for the study.

Example Study Plan Outline for an Airspace Analysis

Problem Statement	Document the nature and severity of the problem and the issues associated with the problem.
Background	Provide background on the problem that the study is intended to address. The background will identify the key stakeholders and their concerns. The background will discuss any key operational details that are relevant to the study.
Scope of Study	Define the scope of the study, especially with respect to constraints such as time, costs, resources, and tools. The complexity of the changes to be studied, the size of the airspace involved, and the level of the potential impact of those changes will influence the scope.
Objective(s) of the Study	Describe the objectives of the study.
Stakeholders and Decisionmakers	Identify the stakeholders that are involved with the study. Describe the relationship of the airspace design team to other organizational entities, including other regions and other study teams. Identify the decisionmakers who will decide if the study conclusions will be implemented.
Products and Schedule	Describe the products that the airspace design team will generate. Establish the date by which the airspace study will be completed. Also establish any interim dates by which interim products will be complete.
Resources for the Study	Describe the staffing and other resources for the analysis. The description of staffing resources should address the knowledge or skills needed, including staff in supporting roles (e.g., data processing and data reduction) in addition to airspace specialists.
Alternatives for the Study	Provide a description of each of the alternative improvements that will be considered and discuss why each is included.
Technical Approach for the Study	Describe the technical approach to be used to conduct the study, including: – the metrics to be used to evaluate the alternatives, – the model or models to be used, if any, and – the data sources to be used. Any key technical limitation that is anticipated should be described to the extent it is known. Describe how environmental issues will be evaluated.

4 CONDUCT AIRSPACE STUDY

Airspace studies can be conducted in more than one way. Depending on the scope of the issue being examined, the analysis could range from assembling experts for brainstorming to performing a few mathematical calculations to building a complex simulation model. Therefore, it is expected that the National Airspace System will become increasingly complex with the infusion of new technologies and concepts such as free flight. It is likely that even minor airspace changes will have far reaching impacts and may require an analysis using modeling tools. The activities to support these types of sophisticated analysis include:

(a) Revalidate problem statement
(b) Select and define metrics
(c) Identify alternatives
(d) Determine type of analysis
(e) Select tool(s)
(f) Obtain input data
(g) Define baseline and alternative scenarios
(h) Adapt, calibrate, and validate model
(i) Make production runs
(j) Analyze model output
(k) Perform sensitivity analysis
(l) Conduct human-in-the-loop studies

Each of these activities is described below in the context of highly sophisticated modeling. Many of the activities are appropriate regardless of the type of analysis and can be applied to a wide range of approaches. If there is a question on what analyses, models, or data are needed to complete an airspace study, the airspace design team should contact ATA-200 for assistance.

a. Revalidate Problem Statement

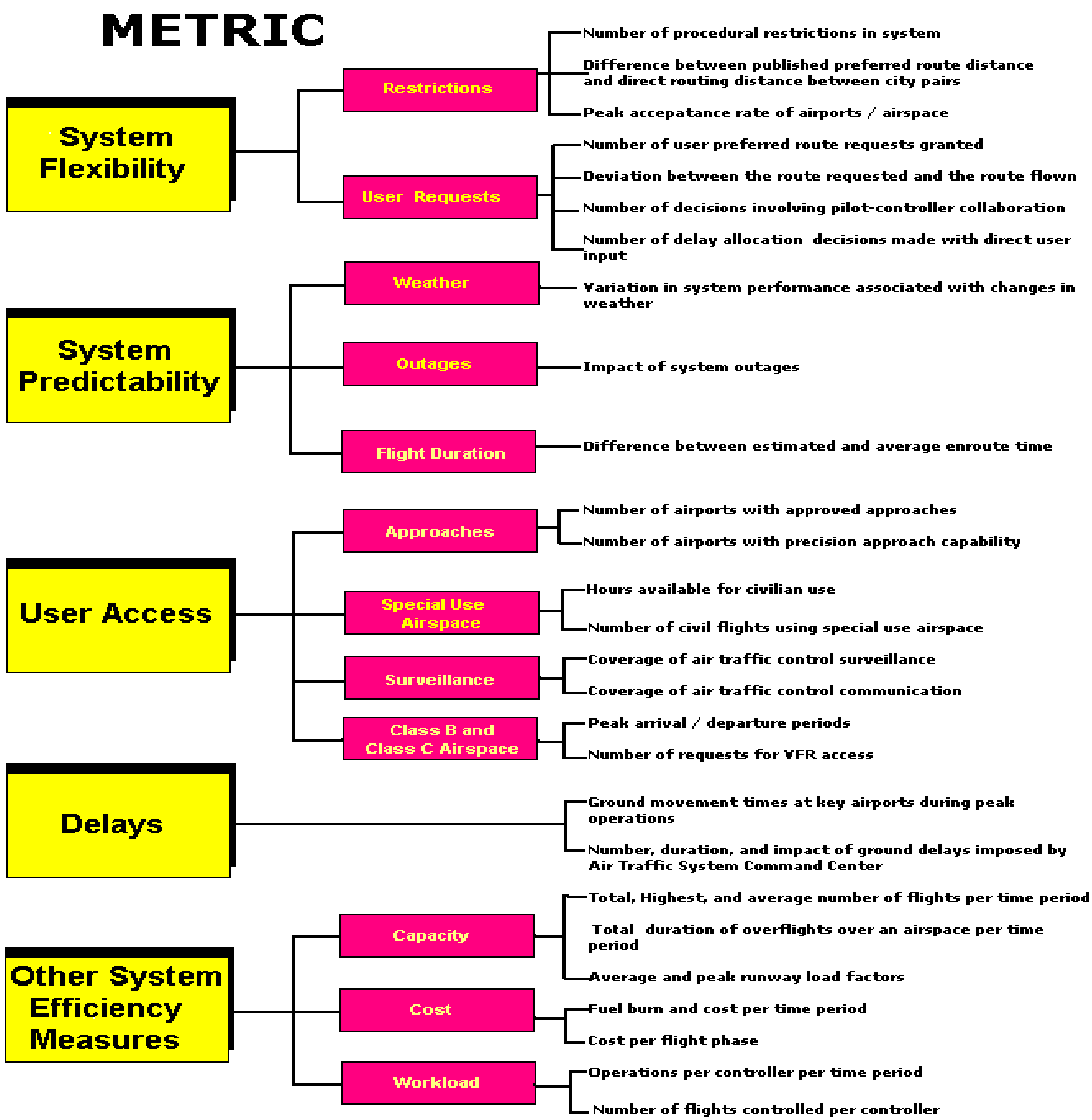
In Steps 1 and 2, the problem was characterized and then an initial evaluation performed. That initial evaluation sometimes leads to a recharacterization of the problem. Before starting the airspace study, the airspace design team must revalidate the problem statement to ensure that the nature and severity of the problem are well-understood, and that the issues associated with the problem have been identified and documented.

b. Select and Define Metrics

Metrics are parameters, algorithms, or formulas used to quantify system performance, and they are measured directly in the NAS or in models of the NAS. Metrics are chosen to reflect the objectives of the airspace improvements. They are the means by which the study team quantifies and reports the results of a study, and so they contribute directly to decisions about airspace changes. Therefore, a clear and consistent set of definitions for metrics is critical to the success of any airspace study.

The selection of metrics is linked to the development of alternatives as well as to the objectives of the study. Before completely specifying the metrics, it is helpful to concurrently specify the study alternatives and the scenarios under which they will be analyzed. The purpose of the metrics is to evaluate the study alternatives under one or more study scenarios. The metrics must enable the airspace design team to differentiate among the alternatives that relate to the objectives of the airspace study.

Metrics and alternatives should be identified early and should be reexamined throughout the study to ensure that they are relevant and consistent with the established NAS goals of system efficiency, safety, and security. The following table identifies examples of metrics related to system efficiency, grouped into categories (indicators) per the *Guidelines for Conducting Airspace Analysis* (RTCA Special Committee 192, National Airspace Review Planning and Analysis).



Finally, metrics definition is very important and should be discussed with the stakeholders to obtain an overall understanding of working interpretations. This contributes to stakeholder concerns being fully addressed during the study. There is an important interrelationship between the study's metrics and alternatives, which must be understood early and reevaluated continuously to ensure the study remains focused on solving the right problem.

c. Identify Alternatives

The airspace design team is responsible for developing a range of alternatives that will be formally studied to quantify the type and degree of improvements over the baseline system. The first step in generating alternatives is to brainstorm possible candidate improvements. The next step is to downselect from among the candidate improvements to arrive at the final set of alternatives for study.

Brainstorm Ideas for Alternatives

Brainstorming is a structured process that the airspace design team can use to generate a wide range of creative alternatives. The goal at the earliest stage of alternative development is to identify and explore various possible alternatives, thus minimizing the chance that good solutions are over-looked. The approach in brainstorming is to encourage each participant to offer alternative solutions or any portion of a solution. Initially, these ideas are not evaluated by the team, since that might tend to dampen creativity or enthusiasm. Rather, the team generates new ideas by building on the initial offerings.

There are several techniques for stimulating creative ideas about alternatives:

- Focus on the problem characteristics and identify alternatives that solve any single aspect of the problem.
- Focus on the objectives of the study and attempt to build alternatives by focusing on each objective, one at a time.
- Enumerate the metrics and suggest alternatives that maximize each of them individually. If there are a large number of metrics, they could be grouped into two or three categories to facilitate the brainstorming.
- Systematically challenge each of the basic assumptions.
- Think about near-, mid-, and long-term solutions.
- Review the NAS Architecture Plan to consider how planned future improvements may be factored into an alternative.
- Review other airspace studies.

Package Candidate Alternatives

This initial phase of generating ideas is followed by a team effort to package the ideas into alternatives that provide a total solution to the original problem. This may involve combining or modifying several ideas. The team should develop each of these alternatives to a comparable level of detail before starting the selection process.

One alternative that should be developed is the "no action" alternative. This alternative provides a benchmark against which proposed improvements can be measured. The "no action" alternative should reflect:

- Other planned improvements to the NAS that may reduce the need for the improvements under consideration as part of the study.
- Prudent management actions that would be taken in order to mitigate performance problems as they evolve (e.g., replace aging infrastructure with functionally equivalent systems when rising maintenance costs warrant doing so).

In general, the "no action" alternative should be defined as completely as any other alternative.

Select Alternatives

After a group of alternatives has been identified, the team must decide on a final list for full evaluation in the study. This may require the team to reduce the number of alternatives. This reduction could be done in stages with progressively tighter criteria.

There are several factors that could be considered in selecting the final set of alternatives:

- Resources available to the study team. If resources are limited, a smaller set of alternatives may be preferred.
- Availability of data or tools to evaluate an alternative. If it is difficult, expensive, or impossible to obtain data for an alternative, or if there are no tools suited to the analysis, then there is less incentive to include the alternative.
- Implementation costs. The list of alternatives should reflect a range of capital and operating costs by all parties involved, principally the FAA and airspace users. While costs will not be known with any accuracy at this stage of the study, rough estimates are adequate. In many cases, modest improvements in performance can be achieved at little cost, while larger scale changes are needed in other cases. If the alternatives span a wide range of investments, it will be easier to draw conclusions about the relationship between implementation cost and performance improvement.

d. Determine Type of Analysis

An airspace study can be conducted in more than one way. Depending on the scope and complexity of the issue, the analysis could be very simple or very sophisticated. As a general rule, an issue should be studied using the minimum amount of effort. This could involve any of the following types of analysis or combinations of them:

- Expert Judgement – Key experts examining all available information and drawing conclusions. If experts come to agreement on the preferred alternative and its impacts, it may not be necessary to perform additional analysis. Expert opinion is also used to supplement the other types of analysis described below.
- Data Reduction Analysis / Statistical Analysis – Analysis of data to gain insight about important variables: distribution among categories, average characteristics, extreme values, and relationships with other variables. This type of analysis could provide insight about the impacts of alternatives. In some cases, this analysis may be compelling enough to stand alone. In other cases, it is a part of the overall analysis.
- Trend Analysis – The examination of historical data, usually with the aid of a spread-sheet, to provide insight about the general direction of system indicators. This is useful for projecting future trends in the analysis of alternatives.

- Mathematical Modeling – The use of mathematical relationships (usually a series of equations) to represent selected aspects of an airspace analysis. These models are useful in showing how a particular aspect of the airspace system can be optimized, but they often involve a great deal of simplification.
- Visualization Tools – Tools designed to show aircraft traffic and NAS features visually. These tools can re-create flight routes on a computer for examination and can generate some ideas for metrics concerning the routes' performance.
- Simulation Modeling – Simulation of aircraft flights with varying degrees of representation of airspace, airports, procedures, and environmental conditions. These models re-generate flights using a variety of information and can be use to examine the effects of changes in any of the inputs.
- Human-in-the-Loop Testing – Integration of human response with a simulation run to get a pilot's or controller's view of an alternative as simulated in the model. See section l below.

e. Select Tool(s)

There are many factors to weigh in selecting the appropriate tool to be used in the study. None is more important than a tool's ability to generate the metrics defined in Step 4b. If the results of a candidate tool cannot be used to determine whether or not the objectives of the study are being met, other tools need to be considered.

Three other aspects of tools are important to consider before making a final selection: the level of detail provided by the tool, the coverage, and the interdependence of domains.

Level of Detail

The level of detail inherent in tools ranges from very limited ("low fidelity") to very specific ("high fidelity"). Low fidelity tools, usually of the form described in Step 4d as "mathematical models," generate fast, approximate answers with emphasis on relative performance. At the other end of the spectrum are high fidelity tools, usually simulation tools, which typically represent aircraft on an individual basis and move them through the airspace under study. Tools with the lowest level of detail are generally easiest to set up and run, and should be used if they meet the needs of the study.

Coverage

Tools can be classified according to the elements of airspace and airports that they incorporate: (1) en route airspace; (2) terminal area airspace; (3) final approaches and runways; and (4) taxiways and aprons. Combinations of more than one of these components are possible. Some tools may be able to examine entire national or regional systems of airports, terminal areas, and en route sectors. The amount of coverage that is needed for a study depends on, and needs to relate to, the scope of the problem and the alternative solutions.

Interdependence of Domains

Some tools can represent only a single aspect of the air traffic system, such as ground movement or flow through upper airspace, while other tools can represent several aspects of the system and their interaction with each other. The most complete tools simulate the entire air traffic system, from gate to gate. It is important to decide whether interaction or interdependency (for example, between ground and air operation) is important enough to require a multi-domain tool, or if a tool in a single domain is adequate to meet the study objectives. Where environmental factors, such as noise, are sure to affect the airspace design, use of a model that is integrated with the Noise Impact Routing System (NIRS) should be considered.

Other important factors in selecting a tool are:

- Availability of the tool
- Access to model input data
- Level of training / expertise
- Ease of use
- Software support
- Cost
- Underlying assumptions

Not every airspace design team will have all the necessary modeling tools or other resources to complete an airspace analysis in the most desired and efficient manner. The airspace design teams are encouraged to take advantage of resources available from ATA-200 to assist in the conduct of airspace studies.

f. Obtain Input Data

The following types of data are typically required in airspace studies, depending on the type of analysis and the analysis tool selected:

- Waypoints
- Routes
- Airports
- Sectors
- Special Use Airspace
- Traffic
- Navigation and Surveillance Equipage
- Procedures and Rules
- Winds and Weather
- Aircraft Performance
- Geography and Terrain

Different types of studies place different demands on the data collection effort. To use airport data as an example, a low-fidelity study of the NAS may require information about the locations of airports or their runway capacity. In contrast, a localized study of high fidelity may require information about runway orientation, restrictions on usage, and DPs and STARs.

In some cases, it may not be possible to obtain the type and quality of data that corresponds to the study's metrics, alternatives, and tools. Adjustments could be made in any of these areas to balance data availability with the needs of the study.

There is often considerable difficulty and controversy in generating the traffic demand that will be used in the study. Depending on the scope of the study and the tools, the traffic description can be simple (number of flights, for example) or complex (information for each flight to include type of aircraft, departure time, and flight path). There are FAA sources, including ETMS data or SAR data, that can be used to generate traffic demand in either form. Any traffic demands derived from observations made in the NAS can only be assumed to represent typical patterns at the time the data was collected, and cannot be automatically extended to estimate future traffic demand. The projections of future demand are more speculative and are developed as part of the airspace study.

g. Define Baseline and Alternative Scenarios

In an airspace study, a baseline scenario is developed to quantify the current state of the airspace and its traffic. The baseline also provides a point of reference from which the effects of airspace changes are evaluated.

Various techniques have been used in past studies to select baseline traffic and weather, including:

- Using a typical VMC day.
- Using a typical day pulled from the peak month.
- Using an IMC day that is selected for weather characteristics of particular interest.
- Constructing or engineering a day from actual data over multiple days.

The choice of technique to use for baselining depends on the objectives, assumptions, and alternatives of the study. These techniques are limited in two ways. First, the baselines produced by the techniques described above are only locally valid. For example, a "good" VMC baseline day in the study area may be a "poor" day in the rest of the NAS. If the baseline day only applies to the local area, it can be difficult to assess the impact of proposed changes on the NAS. Second, none of the techniques capture the day-to-day variability that arises from traffic flow, weather, system outages, etc.

Statistical baselining is an alternative methodology that allows the airspace redesign team to evaluate the current state of the airspace, incorporate the day-to-day variability of the traffic and airspace into the baseline, and link the impact of a local airspace change to the regional and national level. Statistical baselining starts with an analysis of actual traffic over many days to characterize the variability in the system. It uses this statistical information to identify distinct groups of days, each representing a different state of the airspace. A baseline traffic day is drawn from each of the groups and run separately in the tool. One of the implications of statistical baselining is that more runs are required since more baseline days will be generated.

Step 4c described the process for selecting alternatives. In this step, the alternatives are defined to the point where they can be modeled and evaluated. The alternatives build on the information developed in baselining, expanding as necessary to represent future traffic flows or different weather, airspace structure, airport configurations, or procedures.

h. Adapt, Calibrate, and Validate Model

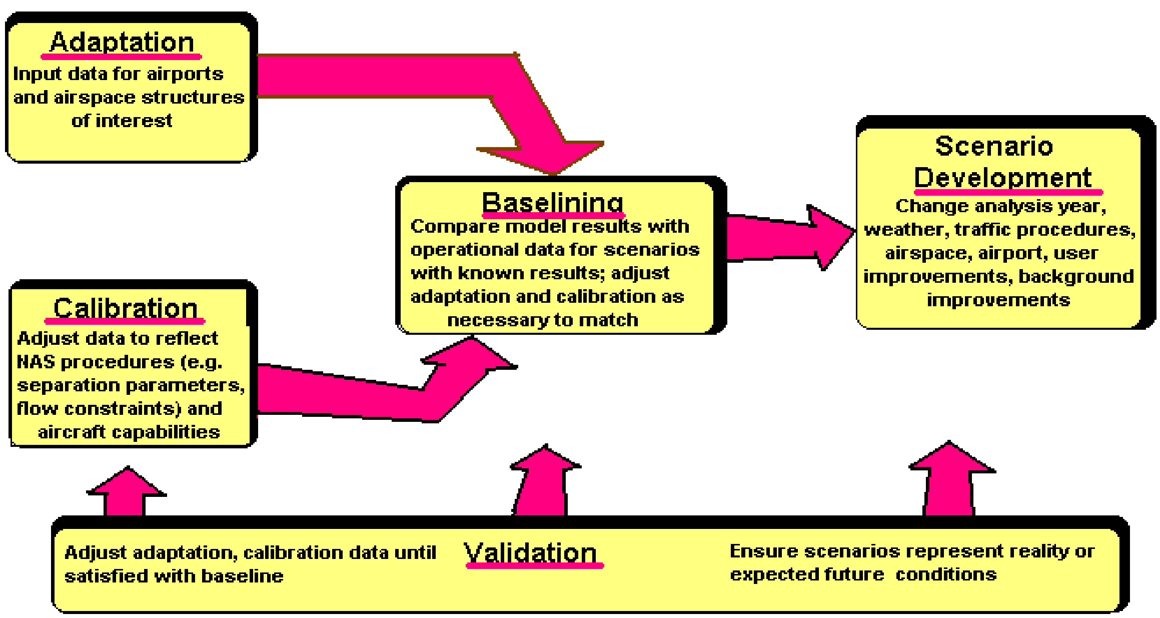
The terms adaptation, calibration, and validation can mean a number of things when used in conjunction with airspace studies.

- **Adaptation** refers to the data used during a study to represent the specific facilities, sites, or NAS resources being modeled. Examples include data describing airports, airspace structures, or traffic scenarios.
- **Calibration** refers to adjustments made to tailor the behavior modeled by the tools to reflect new or changed NAS or aircraft capabilities. Examples include separation parameters or flow constraints.
- **Validation** refers to the steps taken to ensure that the model will provide reliable results for the specific study. It is important to validate the baseline and all the alternatives. The principal mechanism for validation is review by team members or consultants with domain expertise, in addition to those with modeling and analysis skills.

Adaptation and calibration are both used to align the results from analysis of the baseline scenario with measurements of the real system. Small differences in metrics for these two cases indicate that the adaptation, calibration, and tools are adequately modeling the actual situation. If the differences are too large, changes to the adaptation or recalibration may be required to reduce the differences.

Validation of the model is most effective as an iterative process. As each pre-production run is made, the output can be reviewed to determine how well the model represents reality or the alternative under investigation. Reviewers and modelers work together to make appropriate adjustments, continuing the process until there is agreement that the model is valid.

Additional confidence in the overall study approach could be gained by defining multiple baseline scenarios that span a wide range of current conditions and by checking the simulation results with the real system for each scenario. Some differences between the simulated and real systems are inevitable. These tolerances need to be established separately for each study.



i. Make Production Runs

The analysis of alternatives entails exercising the model to predict how the study alternatives will perform under each of the study scenarios. Analyzing all possible combinations of alternatives and scenarios could require a significant number of model runs, which could be time-consuming and expensive to prepare, run, and review. In some cases, a subset of model runs can be selected to compare performance among the study alternatives and scenarios. Advance thinking about the production runs of airspace models will ensure that the results are meaningful and credible. Resources from ATA-200 should be consulted if necessary.

j. Analyze Model Output

Once the model runs are completed, the output results should be examined and comparisons made between the alternative results and the baseline results. The quantitative analysis of metrics often needs to be supplemented with the review by knowledgeable experts who can identify and assess the impacts of alternatives qualitatively. Some of the key consequences of airspace changes may not be captured well by models; for example, safety impacts are not easy to measure from simulation models, but could be evaluated by experts.

Differences among alternatives should be carefully assessed to identify their causes. It is possible that this investigation will suggest revisions to the alternatives that will mitigate impacts or improve system performance. If changes are made to the alternatives, additional production runs are made and analyzed.

k. Perform Sensitivity Analysis

Any large-scale study will require the airspace design team to make various assumptions while modeling the alternatives. Even if these assumptions have a strong basis in precedence and factual information, it is possible that one or more of them will turn out to be invalid by the end the study. Other assumptions are known to be inherently uncertain from the beginning because they are based on imperfect or incomplete information. This is clearly the case for all future events, such as the level and characteristics of the future traffic demand, since the future cannot be predicted precisely.

Questions are likely to be raised about analyses and conclusions based on faulty or uncertain assumptions. One way to protect the integrity of the study and prevent extensive rework is to develop a few scenarios that reflect alternative assumptions for key uncertain elements. Analysis of these scenarios can be used to understand the sensitivity of the results to changes in assumptions. This type of analysis also can be used to bound the uncertainty in the results, given the uncertainty in the input.

l. Conduct Human-in-the-Loop Testing and Evaluation

In some cases, it may be useful to supplement analyses using models with real-time evaluation by experienced pilots or air traffic controllers. Integrating the judgment and performance of a human with the analysis process contributes to the assessment of alternatives from a human factors point-of-view.

There are several tools for integrating pilots' and controllers' inputs into the simulation and analysis process. However, performing human-in-the-loop studies is time consuming and expensive, and the benefit can be difficult to quantify. Therefore, it is important that alternatives have been completely modeled and environmental analyses completed before selecting and analyzing the human factors issues. In the case of a change in airspace design, human-in-the-loop testing relies on using controllers to test the airspace change in real time. Measures for determining merits or faults in the airspace change will likely be based on comments and reactions of the experts testing the airspace design and can be very subjective. Detailed human-in-the-loop studies should be reserved until a point where a study has settled on usable alternatives. A human-in-the-loop study can then be used as one of the final criteria for determining whether an alternative is sufficient from the viewpoint of the type of experts who will ultimately be responsible for working within the new airspace design.

5 SUMMARIZE AND PRESENT RESULTS

The analyses performed, and the conclusions and recommendations derived from those analyses, should be documented in a formal study report. The formal study report should specify recommended airspace actions, sector realignments, route adjustments, and procedural changes necessary to implement the recommendations. A formal study report is important because it conveys the key findings of the study to decisionmakers and stakeholders. A study report also documents the analysis and recommendations for historical reference. This historical reference could be used by others doing a similar study for a different area or it could provide the basis for a follow-on study in the same area.

Study results may be presented in several ways, the most common being a written document called a study report and a verbal presentation called a study briefing. A study briefing is a good way to quickly present key information to decisionmakers and stakeholders. However, a briefing document is usually not suitable as the only record of the results of a study since a great deal of important and relevant information is usually conveyed verbally during a briefing. A study report is preferable for recording information for future reference. A study report is also used, of course, to present information to the decisionmakers and the stakeholders, usually in greater detail than is presented in the study briefing.

An example outline for a study report is provided at the end of this section. This outline is presented as a guideline and is to be tailored for each study as appropriate. The amount and depth of information presented ought to be driven by the desires of the decisionmakers and the stake-holders, the resources available, and the size and scope of the study. It is good practice to include as much relevant information as possible in the study report given the resources available, making use of appendices as appropriate.

The example outline may also be used when preparing a study briefing. The headings listed represent the key types of information that should be considered for inclusion in the briefing. Typically, a briefing will contain less information than is contained in a study report. However, it is important to address key types of information needed by the decisionmakers and the stake-holders.

When preparing the study results, it is helpful to think in terms of the following questions:

- What is the problem under consideration?
- What are the key issues and concerns surrounding the problem?
- Who are the decisionmakers and stakeholders that will make use of the information?
- What information do they need?
- What information can be provided?

It is also useful to consider the following questions when assessing the study results:

- What is the magnitude and significance of the impacts?
- What is the incidence and equity of the impacts?
  (Who is affected, how often and in what ways?)
- What are the implications of any simplifying assumptions?
- What are the implications of uncertainty in the results?
- Are there related issues or concerns that have not been addressed?
- What are the limitations of the data, methodology, models, or tools used?

When presenting conclusions it is often helpful to organize the results by ranking alternatives by various metrics. This may help the reader to better understand the results. It is also useful to present supporting materials in various forms, including text, graphs, or charts.

The table below is an example outline for the study report. The outline lists the key components and the suggested content for each component.

Example Study Report Outline

Executive Summary	Provide a brief, stand-alone summary of major aspects of the study.
Problem Statement	Describe the problem that was addressed, including the relevant elements of the National Airspace System and the airspace user traffic demand. This includes a description of the relevant procedures, automation, and infrastructure, and the magnitude and character of the airspace user traffic loads placed on them. This may also include descriptions of the National Airspace System in future years, its expected capabilities, the corresponding airspace user demand, and the expected system performance.
Background	Provide background on the problem addressed by the study. Identify the key stake-holders and their concerns, and discuss the context in which the study was conducted.
Scope of Study	Describe the scope of the study, especially with respect to constraints such as time, costs, resources, and tools.
Objective(s) of the Study	Describe the original objectives of the study and any changes to them.
Stakeholders and Decisionmakers	Identify the stakeholders that were involved with the study. Describe the relationship of the airspace design team to other organizational entities, including other regions and other study teams. Describe the input received from the stakeholders.
Alternatives for the Study	Provide a description of each of the alternative improvements that were considered and discuss why each was included in the study. The description may briefly discuss the alternatives considered in the early stages of the analysis, but should describe in detail the alternatives as they evolved in the later stages of the study.
Technical Approach for the Study	Describe the technical approach used to conduct the study, including: – the metrics used to evaluate the alternatives, – the model or models used, if any, and – the data sources used. Describe key technical limitations. Describe the approach for evaluating environmental issues.
Results of the Study	Document the expected impacts for the baseline and for each of the alternatives considered. Quantify the results using the metrics described in the technical approach.

Conclusions	Provide a discussion of the key observations that resulted from the study. These may include any conclusions made during the course of the study, including ones resulting from the initial evaluation of the problem, from discussions among stakeholders, and from the modeling and analysis of the alternative solutions considered. Some of the conclusions may focus on matters that were outside the specific scope of the study.
Recommendations	Outline recommendations focusing on which of the alternative solutions should be implemented. Other matters also may be addressed, such as other alternatives that should be considered or needed improvements to the analytical approach or methods.
Appendices	Include in the appendices any detailed explanatory materials. These could include the initial evaluation report, the study charter, and the study plan, as well as the details of the analysis methodology and the analysis results.

6 PLAN IMPLEMENTATION AT FIELD FACILITY

Careful consideration of actions necessary to implement recommended airspace changes should be a part of the overall planning and study process. Although implementation issues ought to be considered throughout the study process, detailed implementation planning should begin immediately after approval for the airspace change. Detailed implementation planning is necessary for airspace changes in order to avoid any interruption of air traffic services, to minimize any disruption of air traffic, and to communicate what airspace changes are to occur. Facilities implementing an airspace change should develop an Implementation Plan to enumerate all implementation activities and a Transition Plan to provide details of the cutover to the new configuration. Together, these two plans should lay out an achievable schedule and describe the steps required to successfully coordinate and enact the airspace change. Involvement of the users is imperative in developing the Implementation and Transition Plans, and in actually implementing the airspace changes.

For changes affecting multiple facilities, the regional office airspace manager will be responsible for coordinating the Implementation and Transition Plans. For changes impacting multiple regions, either ATA-200 or the Airspace Liaison Team will be responsible for this coordination.

Implementation Plan

The Implementation Plan specifies the objectives of the activities along with the necessary activities to be accomplished. These activities should be identified first as major tasks and then as subsequent subtasks. The airspace design team should prepare a checklist or work breakdown structure of the tasks and subtasks. The work breakdown structure should assign or identify facilities, offices, or persons responsible for accomplishing each task. The airspace design team should coordinate, throughout implementation and transition, with the controlling facility airspace and procedures staff in determining the cost and impact of each of the tasks and subtasks.

Once an implementation decision has been made, the facilities airspace and procedures staff provides oversight of the implementation. If other facilities are impacted, the airspace and procedures staff should involve the regional airspace and air traffic operations managers.

Implementation activities include:

Implementation Plan Outline

Coordination	Provide adequate notice of the airspace change to the impacted parties to ensure that service providers, aircraft operators, and all affected stakeholders are fully prepared for the change. Coordinate with FAA and non-FAA facilities experiencing traffic flow changes (increases, decreases, new patterns, new routing, different hand-off points) to ensure that any preparations (internal traffic management, staffing, and workload balancing) can be planned. Coordinate with FAA regional and headquarters personnel on many procedural and logistics functions. Ensure that the schedule and timing of the transition is coordinated with affected facilities.
Scheduling	Develop a schedule for the airspace change and identify milestones for required activities. Scheduling is a key activity in that critical path events need to be aligned to ensure that events with dependencies occur in the proper order and that overall implementation delays are minimized.

Infrastructure Management	Identify the changes to be made to relevant aspects of the airspace infrastructure, including airspace classification, airways, Standard Instrument Departures, Standard Terminal Arrival Routes, and navigation aids.
Equipment and Software	Ensure the equipment and software necessary for the airspace change to be effective is in place.
Procedures	Identify and coordinate procedural changes necessitated by the airspace change, both in the controlling facility's airspace and in neighboring airspace.
Logistics Support	Identify and obtain support requirements, including installation or facility modification or rearrangements; updates to maps, charts, and other documentation; and other preparations for the new environment.
Environmental Support	Determine the type of environmental assessment that will be required and coordinate with the environmental specialists at the region or FAA Headquarters to provide it.
Training	Ensure that training associated with new flight patterns, procedures, workload requirements, or means of operation is conducted prior to the airspace change. This applies to all FAA facilities impacted by the airspace change.
Performance Metrics	Define tools and means to monitor the performance of the airspace change, as recommended by the airspace design team. These are often subsets of the metrics used in the study.
Risk Mitigation	If the steps outlined for action in the plan are followed, the risk factors associated with airspace and procedural changes will be minimized. Proper planning, coordination, simulation modeling, and operational testing permit a thorough testing of new procedures. For each risk identified, the Implementation Plan or the Transition Plan, as appropriate, should define courses of action both to reduce the risk of occurrence and to minimize the impact if the risk occurs.
Back-up Procedures	Develop contingency plans for each possible failure mode identified so that the possibility of a service interruption is minimized or eliminated.
Transition Planning	Identify the steps that will lead to the development of a Transition Plan. Identify elements of transition planning with long lead times and schedule activities to ensure timely completion.

For major airspace changes, a phased implementation should be considered if:

(a) this would reduce risk,

(b) the full airspace change is dependent on future events or installations, but elements of it could be implemented sooner to the benefit of National Airspace System users or service providers,

(c) some elements of the change are ready for implementation, but other elements of the change are risky or need more planning, or full or immediate implementation might create unnecessary complexity.

Transition Plan

For airspace changes, the controlling facility airspace and procedures staff should work with the airspace design team to develop a Transition Plan. The Transition Plan should be based on the Implementation Plan, and provide details of the transition and cutover from the base case airspace configuration to the changed airspace. The Transition Plan need not be a formal publication, but the process and schedule of the transition should be communicated to facility staff, the region, National Airspace System users, and affected stakeholders.

The primary purposes of the Transition Plan are:

- to ensure that there is no interruption or disruption of services,
- to ensure that directly affected parties, including authorities in neighboring airspace and NAS users, are aware of and prepared for the change, and
- to provide clear direction in the event of foreseeable potential transition problems.

The Transition Plan should specify the exact time of the cutover and the exact changes taking place so that directly affected parties are prepared for the change. The cutover is usually conducted during a period with a minimum level of traffic.

Successful transition to an airspace change requires notification of and coordination with all affected parties. Coordinating the exact timing of changes and communicating the complete scope and magnitude of changes is critical.

Preparations should be made so that both the FAA service providers and NAS users can transition smoothly from the base case to the changed airspace. In addition to any required equipment or software being in place, any changes in displays or formatting should be complete and the affected facilities should have updated maps, charts, and any other documentation. At the time of the cutover, updated materials should be available to FAA service providers and NAS users.

If the airspace change includes new operational procedures, training and human factors evaluations should be complete so that FAA service providers and NAS users are fully prepared to operate in the changed environment.

Any changes to standard departure procedures (DPs) and standard terminal arrival routes (STARs) require coordination between the affected control tower, terminal radar approach control, and en route center. While all facilities would have been involved in the airspace design and analysis phases, close coordination of scheduling, training, implementation timing, procedures, and staffing (i.e., appropriate sectors or areas covered) is essential.

Within the FAA, documentation of changes to airspace, procedures, airways, DPs and STARs, and sectorization should be coordinated with ATA, which maintains the airspace baseline, and impacted regional offices. This documentation includes maps, charts, displays, and airspace usage documents.

If there is a major shift in flight patterns, which would cause a major increase or decrease in traffic to neighboring airspace, the change should be closely coordinated with the appropriate authorities so that staffing planning decisions can be made. Generally, the airspace design team will have coordinated with the facilities involved, so the primary concern is coordinating the timing of the change and, if necessary, any training, procedural changes, or agreements between facilities. Similarly, any changes impacting FAA-delegated airspace must be closely coordinated with the authorities of the impacted entity so that the timing of the change is synchronized.

7 EVALUATE IMPLEMENTATION

Continuous monitoring and evaluation is necessary to measure the success of airspace changes. Once in place, changes to the National Airspace System should be assessed to verify that the objectives specified in the Implementation Plan are achieved, to provide lessons learned concerning the change process, and to ensure improved service to users of the National Airspace System.

The three primary monitoring methods are:

- Feedback from stakeholders
- Operational monitoring
- Performance metrics

Feedback from Stakeholders

Feedback on airspace issues is highly encouraged and should be directed to facility airspace and procedures staff, the regional airspace manager, or ATA-200, depending on the level of the impact. That is, a local issue within one facility's airspace would be worked at the facility level by the facility staff; a flight path issue impacting multiple facilities within one region would be directed to the regional staff; an airway or longer-range navigational issue traversing regional boundaries or a policy issue would be elevated to ATA-200 at FAA headquarters. Feedback on operational issues should be directed to the facility operations staff, the regional operations manager, or the office of airspace operations (ATO), depending on the level of impact. Feedback on environmental issues should be directed to the regional environmental specialist or ATA-300, depending on the scope of impact.

All feedback will be assessed to determine if it identifies valid concerns regarding the airspace change, if it proposes reasonable actions, and whether any action should be conducted or considered by the FAA. The responsible FAA authority should respond to the stakeholder by reacting to the feedback in a timely manner.

Any feedback regarding alleged problems, non-compliance with standards, or failure to meet objectives should be verified by the FAA. Most airspace and operational issues are verifiable using performance metrics. Once performance metrics have been evaluated and any other applicable investigation is complete, the facility (for local impact only) or regional (for broader impact) airspace or operations staff will make recommendations regarding any further action.

Operational Monitoring

Many of the earliest comments on an airspace change are likely to come from air traffic controllers, traffic managers, and other facility staff. They are likely to identify airspace and operational problems, as well as workload and capacity (for both service providers and airspace) issues. For these reasons, it is essential for the implementing airspace and procedures staff(s) to coordinate with the FAA service providers. Some workload and operational issues may be resolvable through minor adjustments transparent to the users of the National Airspace System. For other issues, operational monitoring observations should be treated similar to feedback issues.

Major users of the airspace also may monitor performance and report results to the field facility implementing the change. Such data can be useful in identifying strengths and weaknesses of the airspace change, but should be validated. Additionally, since this type of data often reflects the experience of just one airspace user – even if the primary user – the interests of all airspace users must be considered before any action is taken.

Performance Metrics

Ultimately, the validation of feedback from stakeholders and operational monitoring is achieved through analysis of performance metrics. Metrics are selected to provide quantitative measures of performance and to determine if the goals of the airspace change and estimated benefits and operational impacts are being realized.

The performance of the airspace design change should be monitored to determine if the design achieves the predicted performance levels. The lead organization may appoint the airspace design team or a subset of individuals or a regional airspace specialist to conduct the monitoring exercises. Where the airspace change involves just one facility, the implementing facility's airspace and procedures staff and operations staff should be involved in monitoring the performance of the airspace change.

Generally, the metrics to be used are those used in the analysis of the airspace designs. Both positive and negative performance metrics should be measured for the FAA, users of the National Airspace System, and environmental impacts. If potential benefits or costs not included in the analysis are identified, they should also be added.

The airspace design team monitors and documents performance for review by facility and regional airspace and operations managers. For airspace changes with impact beyond regional boundaries, an after-action memorandum should be sent to ATA-200. Important findings or results may be briefed to the airspace liaison team.

The After-Action Report should follow the format shown below. Other documentation of performance monitoring and metrics assessment, such as the after-action memorandum, could be less formal but should include the same key elements.

Example After-Action Report

Objectives	Describe what the change is expected to achieve.
Description	Describe changes to airspace, procedures, or equipment.
Metrics and Baseline	Specify the performance metrics and quantify the pre-change performance. Include the date of the baseline.
Post-Implementation Performance	Include the following items: • Day(s) selected for new baseline and rationale. • Data sources, methods, and any calibration or extrapolation required.
Summary	For better results than expected: provide reasons or observations. For results less than expected: provide reasons or explanations (in particular, note technical and operational issues, other problems, or problems with the study or prediction).
Additional Steps (Optional)	If applicable, describe steps to be taken to improve on less-than-expected results or to enhance airspace change.

GLOSSARY

The definitions contained herein apply only to the usage of these words in the context of conducting airspace design analysis. In other contexts, these words may have different meanings.

adaptation -- Adaptation refers to alignment and relationships of the data used during a study to represent the specific facilities, sites, or NAS resources being modeled. Examples include data describing airports, airspace structures, or traffic scenarios.

alternatives -- Specific alternative sets or packages of airspace changes that:

- Airspace planners develop to address the specific needs, problems, or objectives of the study,
- Members of the study team analyze to assess their attractiveness in meeting study goals and objectives, and
- Decision makers will consider for implementation as part of the proposed solution.

The alternatives may also include other related non-airspace changes (e.g., required NAVAID changes) that are specifically necessary to study alternatives. Other changes to the NAS, for which implementation decisions are yet to be made in other studies or contexts, should not be incorporated in the study alternatives (per se) but instead should be represented in scenarios, as appropriate. (from RTCA SC-192, Vol II)

assumption -- An expected condition, occurrence, event, or status. Here, "assumptions" are used to define a future environment, and refer to most likely parameters for analysis. All assumptions in an analysis should be documented.

baseline -- A replication of actual traffic in a model. After calibration, the baseline becomes the point of reference against which alternatives are to be measured.

calibration -- Calibration refers to adjustments made to tailor the behavior modeled by the tools to reflect new or changed NAS or aircraft capabilities. Examples include separation parameters or flow constraints.

delay -- The term delay has two decidedly different definitions in air traffic management. These two definitions are also used in different ways in different contexts by different organizations, further exacerbating the confusion. Flight delays generally refer to one or the other of the following:

- Delay versus ideal operations (operational delay). These delays are the difference between the actual time required to complete a specific operation (e.g., a flight, a sector crossing, an approach) compared to some ideal, minimum, or unconstrained time. These delays are generally associated with congestion or adverse weather conditions (e.g., time spent in departure queues).

- Delay versus schedules (schedule delay). These delays are the difference between the actual time when a specific event occurred (e.g., pushback, passing a waypoint, arriving at a gate) compared to the time when it was planned or expected to occur. Airline on-time reporting or schedule compliance track this type of delay. These delays generally result from greater than anticipated operational delays.

One should realize that it is possible for a flight to incur an operational delay, but not a schedule delay, if the operational delay was anticipated and already built into the flight schedule. It is also possible, conversely, for a flight to experience a schedule delay and no operational delay, if, for example, the subject aircraft was late in arriving from its previous leg, and thus pushed back late.

Different organizations place thresholds on the minimum reportable delay. FAA counts only delays of 15 minutes or more in its Air Traffic Operations Management System and the Department of Transportation characterizes on-time performance in terms of flights arriving within 15 minutes of the scheduled arrival time. On the other hand, air carriers routinely focus on delays of a few minutes or changes in average flight times of a single minute. (from RTCA SC-192, Vol II)

environmental assessment -- A concise document, describing the environmental impacts of a proposed Federal action and its alternatives. It includes a description of the proposed action, the reason for it, alternatives considered, the environmental consequences (all categories), and possible mitigation actions. (Refer to FAA order 1050.1)

metric -- A mechanism used to assess the performance of organizational functions, processes, or systems. The term metric should be equally applicable to real and to simulated systems. A metric definition should specify two things: the performance data to be analyzed, and a formula or algorithm for extracting a single value from that data.
In simulation, metrics are first calculated for a baseline scenario and then for any alternative scenarios. The results are then analyzed to predict how performance might change if the alternative scenarios were implemented. The performance values calculated are often approximations. In such cases, the general trend (whether things get better or worse) is often more important than the absolute values calculated. (from RTCA SC-192, Vol II)

model -- A defined representation of a system for the purpose of studying that system. In most cases, a simplification of a system, yet sufficiently detailed to permit valid conclusions to be drawn about the real system. Models can be classified as mathematical or physical, with a mathematical model using symbolic notation and mathematical equations to represent a system. (from RTCA SC-192, Vol II)

parameter **--** A measurable factor or characteristic that helps define a system and its behavior.

Examples are average time in sector, controller capacity, arrival capacity, or average fuel use in specified airspace.

performance -- The level of capabilities and operational results, generally expressed in terms of measurements of operational parameters.

scenario -- A set of assumed conditions, generally associated with a specified time period, under which one or more study alternatives will be evaluated. A scenario is generally defined in terms of:

- Specific assumptions about changes to the NAS that are independent of the study alternatives (e.g., planned improvements to ATM/CNS procedures and infrastructure that are expected to be made whether or not the proposed airspace changes under consideration are made).
- Specific assumptions about changes in demand (e.g., growth in traffic, changes in fleet mix, temporal distribution). These changes will be reflected in a specific traffic loading (i.e., a set of specific planned flights) used in the scenario.
- An assumed set of weather conditions relevant to the airspace under analysis (e.g., airport weather, winds aloft, etc.).

(from RTCA SC-192, Vol II)

sensitivity analysis -- The evaluation of the sensitivity of analytical results to changes in base case assumptions, parameters, or most likely occurrences. Typically, a sensitivity analysis evaluates the identified risk and uncertainty factors to determine their impact on the base case most likely results. If a change or variation in an assumption, occurrence, or parameter has a significant impact on the results, the results are said to be sensitive to plausible changes in that factor.

simulation -- The imitation of the operation of a real-world process or system over time using a model. Whether done by hand or on a computer, simulation involves the generation of an artificial sequence of events for a system, and the observation of that sequence to draw inferences concerning the operating characteristics of the existing or proposed system. (from RTCA SC-192, Vol II)

validation -- In the context of this document, validation is the process of confirming the results of the fast-time simulation study through careful scrutiny of model outputs and comparisons of these outputs with actual data, real-time simulations, and post-study implementation tracking. (from RTCA SC-192, Vol II)